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SOLAR PLASMA DIAGNOSTICS EXPERIMENT

SEMI-ANNUAL CONTRACT REPORT

Contract NAS5-32147

Period of Performance
1 November, 1993 through 31 March, 1994

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1 Introduction

The subject of this investigation is the study of the physics of the Solar Corona through the use of high resolution soft X-ray spectroscopy and high resolution ultraviolet imagery. The investigation includes the development and application of a flight instrument, first flown in May, 1992 on NASA sounding rocket 36.048. Effort on the program during this reporting period was concentrated on the preparation of the payload for its second flight in April, 1994.

Experience gained from the first flight led us to plan several design modifications to the payload to improve the sensitivity balance between the UV and EUV spectrographs, to improve the scattered light rejection in the spectrographs, to protect the visible light rejection filter for the Normal Incidence X-ray Imager instrument (NIXI), and to prepare one new multilayer mirror coating for the NIXI. These modifications were implemented during the reporting period. We also investigated the addition of a brassboard CCD camera to the payload to test it as a possible replacement for the Eastman type 101-07 film used by the SPDE instruments, as this film is no longer being manufactured. (The brassboard camera was developed under Lockheed's Independent Research Program at no cost to this contract.) This camera was included in the experimenter's data package for the Project Initiation Conference for the flight of NASA Mission 36.123, held in January, 1994, but for programmatic reasons was deleted from the final payload configuration. By the end of the reporting period, the payload was essentially ready for flight, and was shipped on schedule in early April. The next report under this contract will discuss the launch support operations and the preliminary results from Mission 36.123.

2 Payload Preparations

This section will discuss the instrument subsystems that make up the SPDE payload, and indicate the modifications / preparations that have been made during the reporting period.

2.1 Dual Range Spectrograph (DRSG)

This is a normal incidence stigmatic system that uses an off-axis paraboloid to form an image of the sun on the entrance slit of a dual toroidal grating spectrograph. One end of the paraboloid is coated for optimum performance in the 1200 to 1400 Å range, and the other end is multi-layer coated for a 40 Å wide band centered around 280 Å. Inside the spectrograph, the two wavelength ranges diverge, striking diffraction gratings designed specifically for each range. The final spectrum image is formed on 35 mm film carried in a Canon T-70 camera back. The spectrographs operate at f/20 and have effective focal lengths of 2 m. Spatial resolution is about 3 arc seconds (Nyquist limited) at the center of the field of view. The spectral resolution is about 7,000 in the EUV and 20,000 in the UV.

The DRSG entrance aperture mask was modified to reduce the collecting area of the UV section so that exposure times will be more nearly balanced with the EUV section. The new mask exposes a 10 cm wide by 2 cm tall area of the UV primary, providing a factor of five decrease in the collecting area. We also decreased the slit width from 25 microns to about 12 microns for a further decrease in the effective collecting area. This change also increased the spectral resolution of both sections of the DRSG. We added a light baffle to the DRSG film transport to improve the isolation between the UV and EUV sections so as to reduce the scattered light level in the latter.

2.1.1 Slit Jaw Camera

The DRSG includes a slit jaw camera for recording the location of the spectrograph slit on the solar disk. The original system consisted of a Canon model T-50 camera body, a lens, aperture stop, and neutral density filters. The slit jaw camera operates in white light. In preparation for the flight of NASA 36.123, we have remounted the lens and camera to eliminate vignetting by the entrance aperture mask, deriving the slit jaw image from the full aperture of the XUV half of the primary mirror. We also increased the aperture of the relay lens and removed most of the neutral density filters in order to improve the spatial resolution of the system. Finally, the Canon model T-50 camera body was replaced by a model T-70 body so that much shorter exposure times could be used. The modified slit jaw camera system has much better imaging properties than the original system.

2.2 Normal Incidence X-ray Imager (NIXI)

The NIXI is a prime focus telescope system in which four spherical objective mirrors are mounted on a turret assembly. Each mirror has a multi-layer coating optimized for a different wavelength band in the soft x-ray range. The turret is indexed between exposures in order to change wavelengths. The soft x-ray images are recorded on film carried in a Canon T-70 motorized 35 mm camera back. A thin aluminum filter supported on stainless steel mesh is used to exclude visible light. NIXI was flown on 36.048, but did not record solar images because of a failure of the thin aluminum filter.

We developed and installed a protective shutter system consisting of a motorized door that covers the camera aperture during launch and recovery and during vacuum operations on the ground. The door is dynamically balanced to reduce any tendency for it to move during vibration testing or launch. A simple electrical interface, limit switches, and appropriate payload harness wiring were added to permit the door to be controlled by the on-board computer.

One new mirror, coated for 63 Å, was prepared and installed. The mirror turret was inspected and found to be in good operating condition. All mirrors were installed and re-aligned, and the instrument focus was re-set.

2.3 H-alpha Imager

This instrument consists of a 3.5 inch diameter Maksutov telescope, a reticule system, a narrow band filter system, and a television camera system. This instrument is fully developed and has been flown in the last five sounding rocket payloads. Its principal function is as an aid to pointing and aspect determination.

In preparation for the 1994 launch, we have refurbished the vidicon detector and re-mounted it, re-established the focus, and re-set the alignment with the DRSG.

2.4 Ultraviolet Imager (UVI)

The UVI has been flown on all previous missions of this program. In past flights, it has been used as an ultraviolet filter camera, making very high spatial resolution photographs at the H-lyman α line and in the continuum near 1600 Å. The wavelength ranges were determined by interference filters placed in front of the focal plane. For the 1994 flight, we have procured a new interference filter designed for 1570 Å. It will replace one of the two H Lyman-α filters that were used on the previous flight.

2.5 EUV Imager (EUVI)

The DRSG and UVI systems both require a type of ultraviolet-sensitive photographic film that is no longer being manufactured. Existing stocks of this film are adequate for the forthcoming flight and one or two more, but will eventually be exhausted. The EUVI system is designed as a flight test of a UV sensitive CCD camera system that can eventually replace the film cameras that are now used. It consists of a normal-incidence multilayer mirror herschelian telescope, a mechanical shutter, a thin-film filter (to exclude visible light) the CCD camera, its electronics, and a digital interface / buffer for transferring the data to the telemetry system. Optically, the EUVI is similar to the NIXI; it has a shorter focal length (2 m vs 2.5 m for NIXI) and operates at the single wavelength of 171 Å. The CCD camera head and electronics are mounted on the aft end of the optical table, next to the NIXI film transport. The multilayer mirror is mounted next to the main junction box, near the NIXI turret. The digital interface / buffer, together with power conditioning modules, are mounted on the optical table on the forward side of the CCD camera head. The interface / buffer is based on an Ampro PC 104 386SX program card. Software in the microprocessor will control the shutter, initiate CCD integration, command on-chip summing and read-out of the CCD, capture the digital images, and buffer and format the data to telemetry. The EUVI system includes a thermo-electric cooler for lowering the temperature of the CCD to about -20 C prior to launch.

Technical difficulties on another program prevented the timely completion of the Lockheed-funded EUVI system, and it could not be fully integrated in time for the 1994 launch. To avoid compromising either the schedule or the technical integrity of the payload, it was decided not to attempt to fly it on NASA 36.123.

2.6 Structural System

The instrument structure is based on a two sided optical table, sized for the 22 inch diameter rocket payload. The table is fitted with a pattern of threaded inserts to allow precision mounting of the optical components of the several telescopes and spectrographs. Thermal stability is assured by the use of carbon-epoxy composite, which has been designed to have a very low coefficient of thermal expansion. A hydrophobic resin system has been used to make the composite, in order to minimize dimensional sensitivity to water content. A support system consisting of end fittings, thrust bearings, and a lateral shear panel carries the launch loads while keeping the optical bench in a strain-free condition following burnout.

The instrument compartment consists of four structural components: two cylindrical sections, an extension ring and the vacuum door. The thrust load is carried by the forward cylinder by means of a spherical bearing assembly that is designed to eliminate torque loads and bending moments on the optical table. This assembly also supplies lateral support to the forward end of the table. The aft end of the optical table is supported laterally and in the roll direction by a shear panel which also contains the instrument apertures. The shear panel attaches to the aft end of the aft cylinder. The two cylinders are separated by an adapter ring that carries a vibration snubber and also serves to support the optical table on a portable work stand whenever the structural cylinders are removed for servicing the instrument. Modified tension joints are used to connect the cylindrical sections to the adapter ring and to the instrumentation compartment at the forward end of the payload. The forward cylinder contains the instrument umbilical connector and a 3 inch vacuum port for evacuating the instrument compartment prior to launch.

The structural system performed nominally during the flight of 36.048. However, the recovery impact caused a collision between the aperture end of the optical table assembly and the vacuum door, damaging the actuator rods on the latter. At our suggestion, an extension ring was manufactured for insertion between the payload compartment and the vacuum door in preparation for the 1994 flight. We also remounted the LISS and MASS sensors and re-arranged internal light baffles so that the payload orientation in the rocket cylinders could be returned to its originally designed position. The damaged vacuum door was refurbished at Wallops Flight Facility.

2.7 Control System

The instrument control system is quite simple, consisting of an on-board microcomputer and appropriate interface circuits. Its primary function is to generate the exposure sequences for the different camera drives. Commands originating in the SPDE Ground Terminal (an Everex 386-20 personal computer) are sent to the on-board computer via an RS232 duplex asynchronous serial communications link. This serial link also returns instrument status information to the SPDE Ground Terminal for display and recording. The baud rate for the serial link is 1200 bits per second. Exposure sequencing and filter settings are controlled either under a program commanded from the ground, or in the event of a communications failure, from a default exposure sequence.

No major modifications to the control system were required, other than the addition of some payload harness wiring to accommodate the new NIXI protective door and the EUVI system. Final programming of the flight E-proms is done in the field, just prior to the flight, and will be covered in the next reporting period.

3 Other Activities

A Project Initiation Conference was held at Wallops Flight Facility in preparation for flight 36.123. The flight requirements and mission success criteria are documented in an Experimenters Data Package that was distributed at the meeting. This data package contains a detailed description of the instrument, a new mass budget, and other technical details needed to prepare for the mission.

The orderly flow of funding continues to be a considerable source of difficulty on this contract. Remaining funds from a prior increment to the contract covered much of the effort reported here. However, unanticipated effort and other expenses have been experienced to the extent that the remaining resources are inadequate to support the 1994 field trip. A request for variance has been submitted to recover these costs. In order to preserve the 1994 launch schedule and avoid further budget impacts, Lockheed management has agreed to provide us with pre-contractual spending authority to cover the variance so that the launch can proceed as scheduled.

4 Plans

In our report covering the next period, we will discuss the field operations and launch of 36.123, and present some of the initial scientific results. It will also review our experience with the new command system, which turned out to be a source of difficulty during the mission. Finally, we will report on papers and presentations that have been based on the results.

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